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ABSTRACT

This paper is concerned with helping elementary and junior high school students interpret and construct graphs. Four types of graphs are emphasized--bar, picture, line, and circle or area. The hypothesis is that students in elementary and intermediate grades are generally insufficiently prepared to use graphs effectively, although they are expected to use them as data sources on a regular basis, particularly in social studies classes. This hypothesis is based on a review of literature on uses of graphs with school age children and on an analysis of three social studies textbook series (18 books). This analysis revealed that 124 graphs were presented with very little background information on graphing knowledge and/or skills. To help social studies classroom teachers overcome this deficiency, information is presented for the four types of graphs on uses, construction, evaluation, type of graph paper, derivation of the data used in the sample graphs, follow-up activities, and interpretation. Teaching strategies are also suggested, including types of questions teachers should ask to guide students through the process of analyzing a graph (open, focus, interpretive, and capstone). Examples of questions are (1) "What is the graph about?" (open question), (2) "What do the numbers arranged along the vertical axis mean?" (focus question), (3) "What happened at a specific date to produce a given effect?" (interpretive question), and (4) "What conclusions can be drawn from this data?" (capstone question). A special note on guarding against bias concludes the paper. (DB)

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Graphing: A Stimulating Way To Process Data

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In their daily lives Americans are often exposed to numbers which are beyond their ability to understand. We read about a multibillion dollar national budget, a million-bushel harvest, the importation of five million barrels per day, and populations of a hundred-million-plus. Do these figures have any real meaning for most of us? The answer probably is no. However, teachers do expect students to use and to understand figures such as these which are collected during the study of a region or a country.

Graphs can make astronomical numbers understandable. Statistical data can be presented in simple and interesting forms through these devices. Comparisons can be made. Relationships which are not readily grasped from tables of statistics or narratives can be shown and clarified.

Business, government, the military, news magazines, and newspapers use graphs to present information in vivid and eye-catching forms. Because graphs are so widely used, the American citizen should consider them to be valuable sources of information and should have the skills to use them.

The four types of graphs that most often appear in textual materials, newspapers, newsmagazines, and other media are *bar, picture, line,* and *circle* or *area.* Each has its own characteristics, strengths and weaknesses, uses, and techniques for construction and interpretation. While authors differ on which is the most difficult to construct, there seems to be a consensus that the above order goes from easiest to hardest. This order, with line and circle reversed, appears to be the order of difficulty for inter-

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pretation.[1] An analysis of three textbooks series—a study which was recently made by the writer—revealed a total of 124 graphs in 18 social studies books. The types and numbers of graphs found were as follows: picture—10, bar—67, line—11, circle—37. The major proportion of the graphs were in intermediate-grade texts. Only six graphs appeared in texts for primary-grade pupils. All four types of graphs were presented in the fifth- and sixth-grade books and, in this writer's opinion, were expected to be used as data sources with little preparation.

Teaching Graphing Techniques

Most of the research on the use of graphs with school-age students is old; and it can be summarized in the statement that most graph construction and interpretation techniques can be learned, if systematically taught, by the time the student is in the sixth or seventh grade.[2]

Several authors have stated that the only prerequisite knowledge and skills to graphing activities are some rudimentary counting skills and the ability to do simple classification.[3] The counting skills of pupils are usually well enough along by the latter half of first grade. With some experience during the first months of school with classification exercises[4] or with classification practiced when describing themselves, their families, and their types of shelter, pupils should have their ability to group data well enough developed by the second or third month of first grade so that graphing activities can proceed.

There is some difference of opinion regarding whether a systematic or a needs approach to teaching graphing techniques should prevail. However, the consensus seems to be that the best approach is using student-collected data and pupils' real experiences and then graphing these data during the students' study of the actual content appropriate to each grade level.[5]

The pattern of content in the primary grades offers opportunities for collecting, processing, and sharing data in numerical form. However, teachers will find that they must move to sources other than textbooks, since few textbooks have a variety of graphs. This is not difficult to do, for population analyses of families, classrooms, and working personnel in the school, family, and neighborhood are often the subjects of study. Transportation and communications are common primary-grade topics which lend themselves to data gathering and processing. Therefore, it is possible within the content of most primary-grade programs to find or create opportunities for graphing activities. As studies move away from the pupil's immediate surroundings in the middle grades, the region, the state, the nation, and the world become the content for study; thus, the opportunities for graphing experiences multiply.

In the middle grades, when the content for graphing activities has moved away from much of the student's direct experience, sources of reliable statistical data on states, regions, and the United States and other countries must be located. *Statistical Abstracts*, the *Minerals Yearbook*, and *Statistical Yearbook* are the sources used in the sections that follow. Of these, only *Statistical Abstracts* would be found in most school and public libraries. While the other resources are useful, *Statistical Abstracts* and one of the almanacs listed below would give a teacher an adequate start.

- *The Book of the States*, Lexington, Ky.: Council of State Governments.
- *The CBS News Almanac*, Maplewood, N.J.: Hammond Almanac, Inc.
- *The County and City Data Book*, Washington, D.C.: Department of Commerce, Bureau of the Census.
- *Historical Statistics of the United States, Colonial Times to 1970*. Washington, D.C.: Department of Commerce, Bureau of the Census.
- *The Information Please Almanac*, New York, N.Y.: Viking Press.
- *Minerals Yearbook*, Washington, D.C.: Department of the Interior, Bureau of Mines.
- *The Stateman's Yearbook*, New York, N.Y.: St. Martin's Press.
- *Statistical Abstracts of the United States*, Washington, D.C.: Department of Commerce, Bureau of the Census.
- *Statistical Yearbook*, New York, N.Y.: United Nations, Department of International Economic and Social Affairs.
- *The World Almanac and Book of Facts*, New York, N.Y.: Newspaper Enterprise Association.

Graph Construction

There is general agreement among authors that making graphs is the best way for the student to learn to use and to interpret them.[6] Each of the common types of graphs—

[1] See: Hugh M. Culbertson and Richard D. Powers, "A Study of Graph Comprehension Difficulties," *A-V Communication Review*, 59 (Spring, 1959): 97-110; John Jarolimek, *Social Studies in Elementary Education*, Fifth Edition (New York: Macmillan, 1977), pp. 276-279; Pearl M. Oliner, *Teaching Elementary Social Studies* (New York: Harcourt Brace Jovanovich, 1976), pp. 251-255; Lewis V. Peterson and Wilburn Schramm, "How Accurately Are Different Kinds of Graphs Read?" *A-V Communication Review*, 54 (Summer, 1954): 178-189; Gene E. Rooze and Leona M. Foerster, *Teaching Elementary Social Studies* (Columbus, Ohio: Charles E. Merrill, 1972), p. 206; Zoe A. Thralls, *The Teaching of Geography* (New York: Appleton-Century-Crofts, 1968), p. 114.

[2] Katheryne Colvin Thomas, "The Ability of Children to Interpret Graphs," in *The Teaching of Geography*, ed. Guy M. Whipple (Chicago: The National Society for the Study of Education, 32nd Yearbook, 1933), p. 494; Mary Tucker Thorp, "Studies of the Ability of Pupils in Grades Four to Eight to Use Geographic Tools," in *The Teaching of Geography*, ed. Guy M. Whipple (Chicago: The National Society for the Study of Education, 32nd Yearbook, 1933), pp. 505-506; Ruth G. Strickland, *A Study of the Possibilities of Graphs as a Means of Instruction in the First Four Grades of the Elementary School* (New York: Bureau of Publications, Teacher's College, Columbia University, 1938).

[3] Everett T. Keach, Jr., "I Can Graph My Class?" *Early Years* (January, 1979): 79; Richard E. Servey, *Social Studies Instruction in the Elementary School* (San Francisco: Chandler, 1967), p. 328.

[4] Hilda Taba, *Teachers' Handbook for Elementary Social Studies* (Palo Alto, Calif.: Addison-Wesley, 1967), pp. 91-96.

[5] W. Linwood Chase and Martha Tyler John, *A Guide for the Elementary Social Studies Teacher*, Second Edition (Boston: Allyn-Bacon, 1972), p. 185; Carol Seefeldt, *Social Studies for the Preschool-Primary Child* (Columbus, Ohio: Charles E. Merrill, 1977), p. 144.

[6] Charlotte C. Anderson and Barbara J. Winston, "Acquiring Information by Asking Questions, Using Maps and Graphs, and Making Direct Observations," in *Developing Decision-Making Skills*, ed. Dana G. Kurfman (Arlington, Virginia: National Council for the Social Studies, 47th Yearbook, 1977), p. 75; John Jarolimek, *Social Studies in Elementary Education*, Fifth Edition (New York: Macmillan, 1977), p. 278; George H. McCune and Neville Pearson, "Interpreting Materials Presented in Graphic Form," in *Skill Development in Social Studies*, ed. Helen McCracken Carpenter (Washington, D.C.: The National Council for the Social Studies, 33rd Yearbook, 1964), p. 206; Carol Seefeldt, *Social Studies for the Preschool-Primary Child*, (Columbus, Ohio: Charles E. Merrill, 1977), p. 245.

bar, picture, line, and circle—has somewhat different uses, limitations, strengths, and techniques of construction.

The Bar Graph

The bar graph is useful when making comparisons of a number of items for one period of time; i.e., the number of boys compared to the number of girls in the first grade, or peanut production in the southeastern states in 1980. On this type of graph, values or quantities are represented by vertical or horizontal bars. Each bar is separated from the one next to it by a space equal to or smaller than the bar. Usually the data are arranged in either ascending or descending order; however, the data may be ordered differently depending on alphabetical, chronological, or geographical order.

The bar graph is the most widely used graph, appearing in the popular press in differing degrees of complexity. Since these graphs are easy to make and read, pupils' first graphing experiences should be with the bar graph.

The following tables and figures contain base data and completed bar graphs constructed from the base data.

Table 1. Consumption of Fuel by Consumer Group, 1977

Consumer Group	*Quadrillion British Thermal Units Consumed*
Utilities	22.5
Transportation	19.7
Industrial	18.8
Residential/Commercial	14.8

Source: *Statistical Abstracts*, 1978

Consumption of Fuel by Consumer Group, 1977

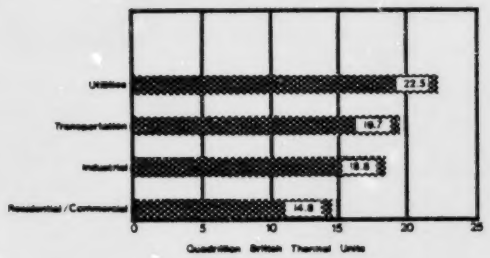

Figure 1

To construct the above bar graph, the following steps are followed:

1. *Construct the axes.* On an arithmetic grid two lines are drawn at right angles to one another; one is the horizontal axis, the other is the vertical. A decision must be made on how the information will be plotted—vertically or horizontally. The bars may be drawn on either axis, depending on convenience and readability. Usually the constant variable is plotted on the horizontal, and the item that varies in quantity is plotted on the vertical axis. However, when working with primary-grade pupils, this principle can be disregarded in order to reinforce the left to right movement of the children's eyes.
2. *Select the unit of measurement.* The unit chosen must show both the smallest (14.8 quadrillion BTUs) and the largest (22.5 quadrillion BTUs); the interval selected is quadrillions. Given the quantities to be shown, an interval of five seems to be reasonable.
3. *Round off the base data figures if necessary.* Graphs do not show information as accurately as do tables. This is because some accuracy is sacrificed for eye appeal.
4. *Arrange the quantities in order.* The quantities to be plotted may be arranged in ascending or descending order, depending on appearance.
5. *Plot the quantity of the amounts on the horizontal axis.* The labels for the quantities are written on the vertical axis. Each quantity is plotted on the horizontal axis, and the final placement is estimated. Note the amounts of fuel consumption written within the bars.
6. *Label the axes.* Quadrillion BTUs are the label for the horizontal axis. The names of the consumer groups become the vertical axis labels.
7. *Determine and write in the title, data source, and date.*

Bar graphs and their primary variation, picture graphs, are considered by most writers to be the simplest to make and to read. In a survey of three elementary-grade social studies textbook series, this writer found that bar graphs were the type of graphs most often used in primary-grade texts.

As suggested previously, graphs should be constructed within the context of the content being studied and, whenever possible, from the pupil's own experience. The data for the graph that appears as Figure 2 were collected during a study of a transportation unit in a third-grade classroom.

Table 2. Number of Vehicles Passing Clarke Elementary School Tuesday, 10:00 a.m.-10:30 a.m.

Car	12
Truck	7
Motorcycle	3
Bus	2
Moped	2
Camper	1
Bicycle	1

Source: Observation

Vehicles Passing Clarke School on Tuesday, 10:00 a.m.—10:30 a.m.

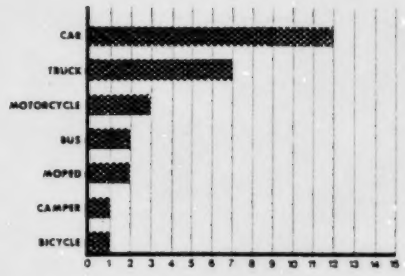

Figure 2

The steps in the construction of the primary-grade bar graph were approximately those described previously. The teacher used graph paper which was drawn on a mimeograph master with one-half inch squares. The pupils were led through the steps of setting the axes,

choosing the unit, scaling, labeling and titling, and recording the quantities. The teacher demonstrated each step and then made certain that the pupils followed suit.

The Picture Graph

Although not as precise as other types of graphs, the picture graph is particularly useful in gaining and holding the reader's attention. It aims to overcome the lack of visual appeal of a bar graph by showing the content with self-explanatory symbols. The symbol is used to represent persons or objects—a definite number or amount. Symbols are usually simple figures such as coins, stick figures of men, women, or children, a car, or bales of cotton. Quantities should be indicated by the *number* of symbols, rather than by the size of the symbol. Users of the picture graph should be aware that its primary disadvantage is its inability to show fractions adequately.

This adaptation of the bar graph is simple to make and to read; its use in the popular press is widespread. Because it can be both simple and complex, it is appropriate for use at all grade levels. However, only after pupils have had considerable experience graphing items familiar to them on a one-to-one basis should they be exposed to the notion that one symbol can be used to represent more than one of a given quantity.

The following tables and figures contain base data and completed picture graphs constructed from the base data.

Table 3. Passenger Automobiles in Use in 1976

North America	122,400,000
Europe	96,910,000
Africa	69,290,000
Asia	24,360,000
South America	10,430,000
Oceania	6,670,000

Source: *Statistical Yearbook*, 1977

Passenger Autos in Use in 1976

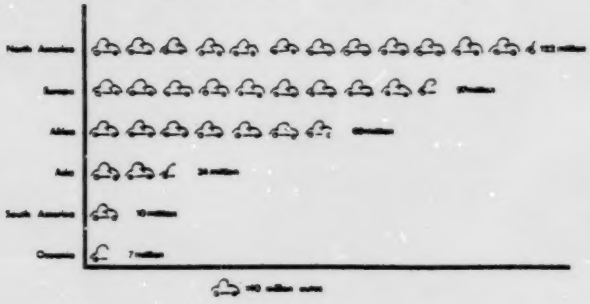

Figure 3

To construct the above picture graph, the following steps are followed:

1. *Select the unit of measurement and the symbol to represent the unit.* As with the bar graph, the unit of measurement chosen must have the capability of showing the smallest value (6,670,000 automobiles) and the largest (122,400,000). The symbol should be one that can be easily represented on a horizontal or vertical line and one that is appropriate to the content of the graph. The unit selected is one symbol of an automobile to equal ten million autos. With other statistics such as cotton production, one bale (▭) might be equal to one hundred, one thousand, ten thousand, or one hundred thousand bales; or with smaller values one stick figure (웃) might be equal to one child.
2. *Round the figures.* To be justified, a picture graph must be easy to read. The accuracy of the graph may be compromised in order to accomplish the effect the graph is intended to produce. However, the values should be shown on the graph as in Figure 3, if at all possible. This practice will minimize the picture graph's lack of accuracy.
3. *Label the axes and plot the data.* In this graph only the vertical axis is labeled with the names of places. If space permits, the symbols are plotted in groups to facilitate counting them.
4. *Determine and write in the title, data source, and data.*

The following data were collected by a second-grade class during a study of conservation of energy. In this example, the data were collected from the whole class, and the graph was a group project.

Table 4. How Our Class Travels to School

Way of Travel	*Number of Students*
Bus	12
Walk	6
Car	4
Bicycle	3

Source: Observation

How Our Class Travels to School

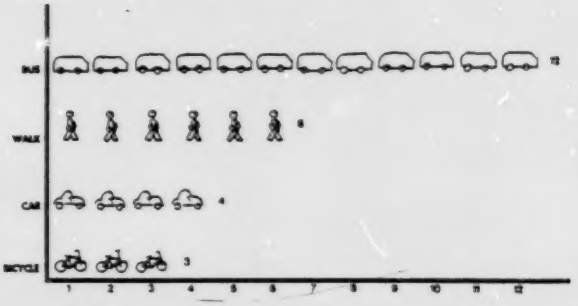

Figure 4

This second-grade class made its graph on a large piece of brown wrapping paper that measured approximately three feet by six feet. The symbols were drawn by the pupils and then pasted on the large piece of paper. Note that this graph has a horizontal axis numbered from one to twelve in order to reinforce counting skills. Also note the one-to-one correspondence of the symbols on the graph. In order to keep the symbols the same approximate size, the teacher had each pupil draw a symbol on a piece of paper that measured approximately three by five inches.

The Line Graph

Perhaps the best known and certainly one of the most frequently used types of graphs is the line graph. This graph is formed by plotting a series of values on a numbered grid in which various values are joined into a continuous line.

The line graph is considered to be the most precise of the four types of graphs. It is particularly useful in showing changes in quantities over measured amounts of time. It is appropriate to use the line graph when there are many

successive values to be plotted, such as daily or monthly changes, and when the reader's attention is to be focused on movement rather than on actual amounts.

One difference between this graph and those discussed previously is that the slope of the line usually indicates rapidity of change in the variable being plotted. Because of this factor, bias can be introduced easily or misinterpretations can be made by the shape of the grid which influences the slope of the line.

Since line graphs are two-dimensional, they are more difficult to construct and to interpret than are bar graphs and picture graphs. Usually initial instruction in making and reading the line graph is delayed until the upper elementary and middle grades.

The following table and Figure 5 contain base data and a completed line graph constructed from the base data:

Table 5. Production of Anthracite Coal in the United States

Year	*Tons Produced*
1890	46,468,641
1900	57,367,915
1910	84,485,236
1920	89,598,249
1930	69,384,837
1940	51,484,640
1950	44,976,703
1960	18,817,441
1970	9,729,398
1976	6,228,233

Source: *Minerals Yearbook*, 1976

Anthracite Coal Production in the United States

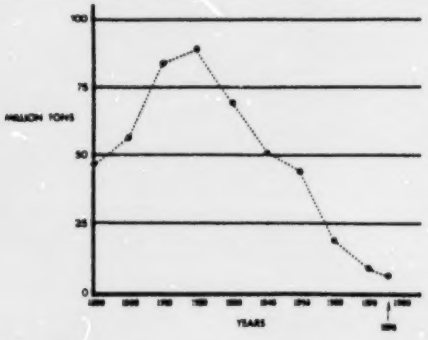

Figure 5

To construct the above line graph, the following steps are followed:

1. *Select or prepare the grid.*[7] In this instance an arithmetic (uniformly spaced) grid is used. The arithmetic grid is most appropriate for use with youngsters because there is less chance for distortion or misrepresentation of the data. Generally, the rule is to use the fewest lines possible so as to not detract from the visual impact of the line slope.
2. *Select the unit measurement and arrange the units on the axes.* On a line graph, one of the variables most often used is time. The time is always plotted along the horizontal axis. Inspection of the data will usually indicate appropriate time intervals. In this instance, the data indicate ten-year intervals beginning with the year 1890 and ending with 1970. Additional data are provided for 1976. Note the spacing between 1970 and 1976. The data also help determine the vertical axis scale. As with the bar graph, the values must show adequately both the smallest and largest values to be plotted (six million and 89 million). In this example a scale of millions is chosen and arranged on the vertical scale; the unit selected is 25. Units of measurement of 5, 10, or 20 could have been chosen, but the increased number of numerals and lines might detract from the readability of the graph.
3. *Points are located on the vertical and horizontal axes.* The points should be plotted as accurately as possible given the data and the grid chosen. The figures are rounded and the point positions are estimated.
4. *Join the plotted points.*
5. *Label the axes.*
6. *Determine and write in the title, data source, and data.*

[7] For a technical discussion of grid preparation, scaling, and point plotting, see Herbert Arkin and Raymond R. Colton, *Graphs: How to Make and Use Them* (New York: Harper and Bros., Publishers, 1936), p. 11.

The Circle Graph

The circle graph is actually an area graph which most often takes the form of a circle. The primary use of the circle graph is to show relationships within a whole. The circle is divided into sections, as in wedges of a pie; each wedge represents a part of the whole and is proportional to the value it represents.

Although the circle graph is relatively easy to interpret, it is difficult to make. To construct this graph the students need to be able to work with fractions, percentage, long division, and two-digit multiplication; and they need to know how to use a compass and a protractor. Therefore, teaching students to make circle graphs usually comes later in the elementary school years or during the middle school.

The following table and Figure 6 contain base data and a completed circle graph constructed from the base data:

Table 6. Energy Consumption Per Capita in the U.S. by Source, 1977

Source	*Millions of British Thermal Units (BTUs) Consumed*
Crude oil	171
Natural gas	91
Coal	65
Water, nuclear, geothermal	24
TOTAL	351

Source: *Statistical Abstracts*, 1977

Energy Consumption Per Capita in the U.S. by Source, 1977

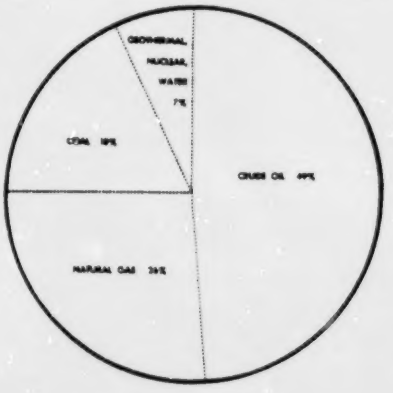

Figure 6

To construct the above circle graph, the following steps are followed:

1. *Prepare the data.* The values of the components must be converted into percentages and then to degrees of a circle. This is done by dividing the amount of British Thermal Units (BTUs) consumed by each source by the BTUs consumed by all. Now the percentages are converted to proportions of the circumference of the circle, which is, of course, equal to 360 degrees. Since the circle represents the total (100%), it may be divided into 100 equal parts. In degrees, each percent will equal 360 divided by 100 or 3.6 degrees. Therefore, each percentage figure is multiplied by 3.6 and rounded to the nearest whole number. It is important to be certain that the multiplication is accurate by summing to 100 percent and 360 degrees. The process may be easier to follow if the students build a table similar to the one that follows:

Source	BTUs consumed		Total BTUs consumed		Percent		Degrees
Crude oil	171	÷	351	=	48.7 × 3.6	=	175.3
Natural gas	91	÷	351	=	25.9 × 3.6	=	93.2
Coal	65	÷	351	=	18.5 × 3.6	=	66.6
Water, nuclear, geothermal	24	÷	351	=	06.8 × 3.6	=	24.4
					99.9[8]		359.5[8]

Round the degrees to whole numbers.

2. *Draw a circle.* A compass is used and the circle is made as large as practical. It is important to be certain that the circle is larger than the protractor to be used.
3. *Mark off a radius.* The midpoint of the circle is identified; then 90 degrees on the protractor is used to draw a radius toward the top of the circle. This is the starting point for plotting the data.
4. *Plot the data.* As a person works clockwise around the circle, the protractor is placed on the radius with its midpoint on the midpoint of the circle. Reading from left to right (0 to 175), the correct number of degrees for the first section of the circle is marked off. In the example, 175 degrees should be read and a mark should be placed at that point on the circle; then a line should be drawn from the midpoint of the circle through the 175 degree mark to the outside of the circle. Each new radius drawn thereafter becomes the base line for the section to be plotted next. Working clockwise around the circle, one plots each source in degrees after the first and largest (175) to the smallest (24) until all four sources are plotted.
5. *Label the sections.* The sections within the circle are to be labeled or cross-hatched. If the section is too small to permit adequate labeling, the label is written outside the circle and an arrow is drawn into the appropriate section.
6. *Determine and write in the title, data source, and data.*

Graph Interpretation[9]

In teaching students to process data from graphs, the teacher's strategy is one of moving from a series of concrete, specific encounters with factual data to the higher cognitive levels requiring students to infer, conclude, and generalize. In most instances, it is the student who states the generalization and the teacher who guides the student by asking questions. The teaching strategy requires three levels of operations, which are:

1. Identification of specifics—identifying and examining specific information contained in the body of data.
2. Analysis of relationships—developing and expressing relationships between specifics and explaining the relationships.
3. Generalizing—concluding, inferring, or generalizing from the data.

When guiding students through the analytic process, the teacher relies on questions to convey to pupils their specific thinking tasks. The types of questions used in the process are named "open," "focus," "interpretive," and "capstone." The process calls for the teacher to begin with an opening question, move through a series of focus and interpretive questions, and conclude with one or more capstone questions.

The Open Question

The purposes of the open questions are to (1) center the student's attention on the graph to be analyzed, and (2) point up the content the student is expected to encounter in the graph. Examples of the open questions are:

- Look at the title of the graph. What information do you think it will contain?
- What is the graph about?
- What do you think the graph will tell us?

The Focus Question

The purposes of the focus questions are to (1) identify the technical parts of the graph that are critical to understanding the content, and (2) get the students to examine each part of the graph so that the factual content can be extracted. The technical aspects of the graph to be considered are understanding the axis scales and labels, decoding the symbols, translating the units of measurement, and identifying the source and the date of the data used by the graph-maker. Examples of the focus directions and questions are:

- What does each symbol represent?
- What are the amounts listed on the vertical axis?
- Name the categories along the vertical axis.
- Where did the graph-maker get his or her information?
- How up-to-date is the information?
- How much was spent in 1976 on residual oil?
- How much was produced by Venezuela?

The Interpretive Question

Interpretive questions are designed to help identify and explain the relationships among the specific information contained in the graph. In seeking to elicit comparison, contrast, and relationship ideas, teachers should try to help students to draw out, to describe, and to explain the relationships between two or more points in the data. Examples of interpretive questions are:

- What similarities/differences do you see in the production figures for 1974 and 1979?
- How do the import figures relate to what happened to Americans in 1974 and 1979?
- What do you think consumption will be in 1985?

[8]Because of rounding, at times these columns will not sum to exactly 100 and 360 degrees.

[9]The general process of interpreting data described in this section has been adapted from "Interpreting Data," *Instructor's Manual: Development of Higher Level Thinking Activities* (Portland, Oregon: Northwest Regional Educational Laboratory, 1972), pp. 302-352.

- How do you account for the drop in consumption shown in 1979?
- How does the United States and the Soviet Union compare in number of automobiles? What do you think causes the difference?

The Capstone Question

The purpose of capstone questions is to move the question emphasis to the highest level, that of summarizing, concluding, and generalizing. Examples of capstone questions are:

- What conclusions can be drawn from the graph?
- How could the data be summarized?
- What can be said about energy consumption in the United States during the last ten years?
- What particular meaning does this graph have for you?
- If that is true for Americans, would it also be true for the Canadians? The British? Will it continue to be true for us?
- What is the main idea of all we have been saying?

The process of analysis is designed to help students move smoothly through the stages of identifying and recalling data, to identifying relationships among specific facts within the data, and then to making generalized statements which can be supported by the information.

Based on Figure 5, "Anthracite Coal Production in the United States," examples of the four types of questions that could be used in analyzing the graph are:

Open Question:
- What is this graph about?

Focus Questions:
- What do the numbers arranged along the vertical axis mean? The horizontal axis?
- What was the approximate amount of coal produced in 1900?
- What was the approximate amount produced in 1976?
- In what year was the most coal produced?

Interpretive Questions:
- What is the approximate difference between the amount of coal produced in 1920 and 1976? What events might account for this difference?
- During what years did coal production increase? What conditions prevailed in the United States that could have had an effect on this increase? How could you verify that idea?
- What happened during the 1920s to cause the decline in production? How could we prove this to be true?
- At what point in the total decline in production did the rate of decline decrease? Why do you think this occurred?
- Based on what is now happening to energy sources and costs, what do you think the coal production figures will be in 1980? In 1990?
- What factors do you think will affect coal production and consumption in the United States in the near future?

Capstone Questions:
- What can we say about production of coal in this country?
- What conclusions can be drawn from this data?
- Do you think this has had or will have any effect on your life?

A Special Note: Guarding Against Bias

To this point this booklet has been concerned with the techniques and processes for creating and interpreting graphs. Knowledgeable about the processes associated with graph interpretation, the potential decision-maker should also be aware of the possibilities for the transmission of bias and misinformation through graphic presentations. Calvin F. Schmid writes that "visual relationships portrayed by . . . graphs are more clearly graphed and more easily remembered."[10] Given the power of the visual message, misinformation is as clearly remembered as is correct information. Four major sources of misinformation follow:

Eye Appeal

Some of the most attractive graphs appear in newspaper and newsmagazines in advertisements and in news accounts. Each may have devices such as multiple lines and columns, color, symbols, stylized people, animals, and objects, and they may be drawn in 3-D—all of which are eye-catching. However, the devices which make these graphs so attractive are the devices that may detract from the information contained in the visual. The reader may not be able to concentrate on the factual data because of the confusion of color and action. While eye appeal is the element that sets graphs apart from other information-giving media, it must not overshadow or confuse the information being presented.

Grids and Scales

Perhaps the easiest way for a graph-maker to dramatize plotted figures is to manipulate the data by expanding or contracting the background grid. This manipulation can take place by expanding the vertical scale and keeping the horizontal constant, expanding the horizontal and holding the vertical constant, or using some other combination of expansion and contraction. The distortion that results can change the whole data picture.

Another way to dramatize a graph's message is to stretch the grid: that is, by using inconsistent space for equal amounts of time shown, or by using constant space for unequal amounts of time, or by skipping amounts and years when building the grid. The reader may assume that equal time occupies equal space and thus draw incorrect conclusions because of a failure to attend closely to the figures making up the scale.

Graph scales are the units of value that make up the grid and are plotted on the vertical and horizontal axes of all except circle graphs. One of the most common rules of graphing is that on graphs with an arithmetic base—that is, one showing equal space between values on both axes—the values begin at zero. However, another rule states that numerals may be omitted from scales to conserve space, if so noted by the graph-maker. Grid-breaking is usually indicated by jagged or wavy lines running through the graph at the point where the data are broken or by some other commonly accepted device. A graph that does not conform to these rules is bound to be dramatic. However, it is suspect and may convey misinformation. This is particularly true on complex, commercially prepared graphs that present several sets of related data on one grid. The reader must be certain that all scales begin at zero and that the unit relationship on the scales is constant. If the scales do not begin with zero, it is important to determine why not.

Symbols

The symbols used in picture graphs should take a reasonable and recognizable form. The prime rule is that

[10]Calvin F. Schmid, *Handbook of Graphic Presentation* (New York: Ronald Press, 1954), p. 3.

the graph-maker treat each symbol as having a particular value. It is easy to build distortion into a picture graph, even following this rule, by comparing one small symbol to one larger; for example, comparing a person to an automobile. Since the symbols would be of different sizes, they could convey a false impression if presented without regard to proper spacing. Thus, no matter what the symbol's size, each should be shown on a one-to-one relationship to the other symbols.

Illusions

Illusion can be used by the professional graph-maker to dramatize data. Perspective and 3-D effects can give an illusion that one column is longer or higher, or that a piece of a pie graph is greater than another of equal size. These elements and others can contribute to the eye appeal of the graphed data. However, the data on the graph that cannot be read easily on the background grid are to be mistrusted.

Because visual impressions are more lasting than the factual data they represent, it is imperative that students be aware of the possibilities for the introduction of misinformation into otherwise factual news accounts and into advertising that purports to be factual but intends to persuade. The person who is aware of the possibilities for the introduction of bias and error through the distortion of grid and scales, the use of illusion, symbol placement, and the vividness of the color and movement on the graph is the person who will best be able to interpret the information presented in the graph.

Selected Bibliography

In addition to the references cited in the footnotes, most social studies and audio-visual methods textbooks have sections on the use of graphs. The following sources were found to be helpful in graph construction:

- Herbert Arkin and Raymond R. Colton. *Graphs: How to Make and Use Them.* New York: Harper and Brothers Publishers, 1936.
- Nelson, P. Guidry and Kenneth B. Frye. *Graphic Communication in Science.* Washington, D.C.: National Science Teachers Association, 1968.
- Calvin F. Schmid. *Handbook of Graphic Presentation.* New York: The Ronald Press, 1954.
- Mary E. Spear. *Practical Charting Techniques.* New York: McGraw-Hill, 1969.

NOTE: This *How To Do It* Notebook Series 2, designed for a loose-leaf binder, provides a practical and useful source of classroom methods and techniques for elementary and secondary social studies teachers. The titles now available in Series 2 are: *Improving Reading Skills in Social Studies, Effective Use of Films in Social Studies Classrooms, Reach for a Picture, Using Questions in Social Studies, Architecture as a Primary Source for Social Studies, Classroom Management in the Social Studies Class, Oral History in the Classroom,* and *Using Popular Culture in the Social Studies.* Price per copy $1.00. Quantity discounts: 10-49 copies, 10%; 50-99 copies, 15%; 100 or more copies, 20%. Payment must accompany all orders except those on official institutional purchase order forms. Order from the NATIONAL COUNCIL FOR THE SOCIAL STUDIES, 3615 Wisconsin Avenue, N.W., Washington, D.C. 20016.